EFFAT UNIVERSITY
COLLEGE of ARCHITECTURE & DESIGN
ARCHITECTURE DEPARTMAENT

ARCH350:

STRUCTURE in ARCHITECTURE - I

MOMENT OF A FORCE

Today's Objectives :

Students will be able to:

a) understand and define moment

b) determine moments of a force, and

c) define a couple, and its moment

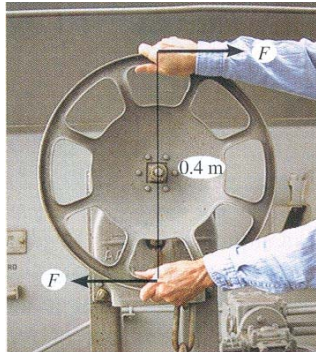**In-Class Activities** :
- Applications
- Moment of a force
- Concept quiz
- Group Problem Solving
- Reading quiz

What is the net effect of the two forces on the wheel?
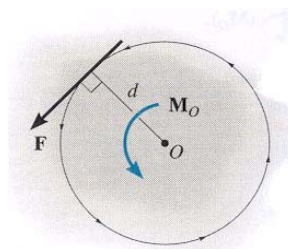

MOMENT OF A FORCE

The <u>magnitude</u> of the moment is

$M_o = F\,d$

As shown, d is the *perpendicular* distance from point O to the <u>line of action</u> of the force F.
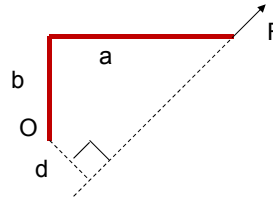

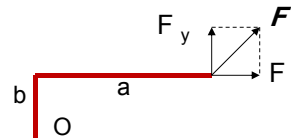The <u>direction</u> of M_O is either **clockwise** or **counter-clockwise** depending on the tendency for rotation.

For example, $M_O = F\,d$ and the direction is counter-clockwise.

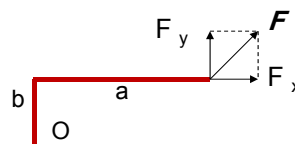Often it is easier to determine M_O by using the components of **F** as shown.
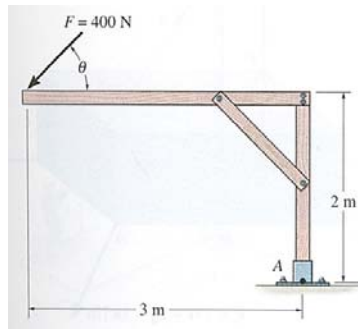
Using this approach,
$M_O = (F_Y\,a) - (F_X\,b)$

Note the different signs on the terms! The typical sign convention for a moment is that counter-clockwise is considered positive.

EXAMPLE 1

F = 400 N

2 m

A

3 m

Given: A 400 N force is applied to the frame and θ = 20°.
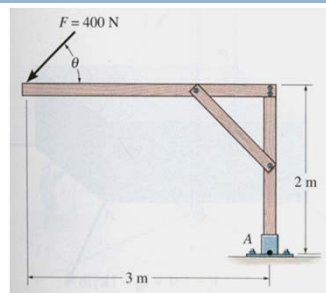
Find: The moment of the force at A.

Plan:

1) Resolve the force along x and y axes.

2) Determine M$_A$ using scalar analysis.

EXAMPLE 1 (CONTINUED)

F$_x$ = 400 cos 20° N (←)

F$_y$ = 400 sin 20° N (↓)

F = 400 N

2 m

A

3 m

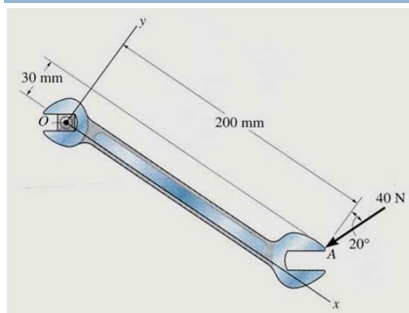+↰ M$_A$ = (400 cos 20°) (2) + (400 sin 20°) (3)

= 1160 N·m

If a force of magnitude 10 kN can be applied in four different configurations (P, Q, R & S), select the cases resulting in the maximum and minimum moment values on the nut and point N (Max, Min).
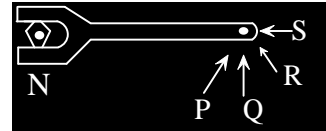
A) (Q, P)   B) (R, S)

C) (P, R)   D) (Q, S)

Given: A 40 N force is applied to the wrench.

Find: The moment of the force at O.

Plan

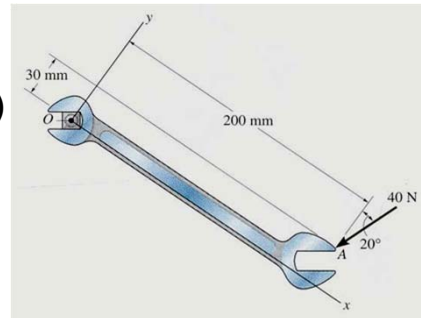1)   Resolve the force along x and y axes.

2)   Determine M_O

$+\uparrow F_y$ = - 40 cos 20° N

Or F_v = 40 cos 20° N ($\downarrow$)

$+\rightarrow F_x$ = - 40 sin 20° N

Or Fx = 40 sin 20° N ($\leftarrow$)

$+\nwarrow M_O$ = -(40 cos 20°)(200) + (40 sin 20°)(30)

= -7107 N·mm = - 7.11 N·m
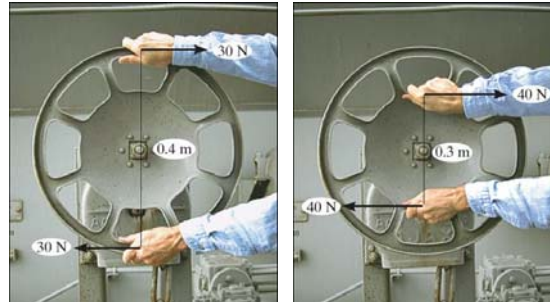
10 N   5 N

3 m   P   2 m

Using the CCW direction as positive, the net moment of the two forces about point P is

A) 10 N ·m   B) 20 N ·m   C) - 20 N ·m

D) 40 N ·m   E) - 40 N ·m

A couple (torque) of 12 N·m is required to rotate the wheel. Why does one of the two grips of the wheel above require less force to rotate the wheel?

In statics, a couple is defined as _____ separated by a perpendicular distance.

A) two forces in the same direction

B) two forces of equal magnitude

C) two forces of equal magnitude acting in the same direction

D) two forces of equal magnitude acting in opposite directions

EXAMPLE
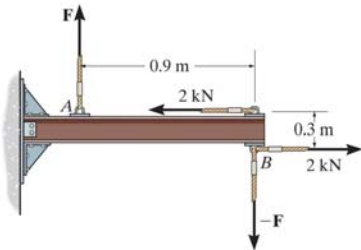
Given: Two couples act on the beam with the geometry shown.

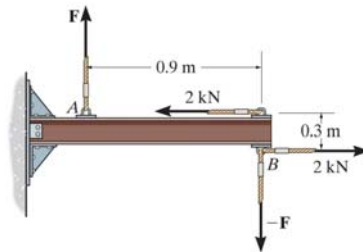**Find:** The magnitude of F so that the resultant couple moment is 1.5 kN·m clockwise.

Plan:

1) Add the two couples to find the resultant couple.

2) Equate the net moment to 1.5 kN·m clockwise to find F.

EXAMPLE 2

The net moment is equal to:

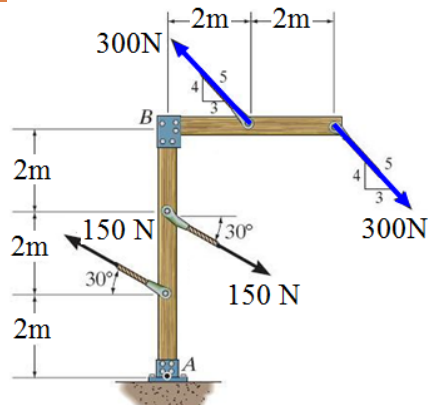$+ \Sigma M = - F (0.9) + (2) (0.3)$

$= - 0.9 F + 0.6$

$- 1.5 \text{ kN·m} = - 0.9 F + 0.6$

Solving for the unknown force F, we get

F = 2.33 kN

EXAMPLE 3

Given: Two couples act on the beam with the geometry shown.

Find: The resultant couple

Plan:

1) Resolve the forces in x and y-directions so they can be treated as couples.
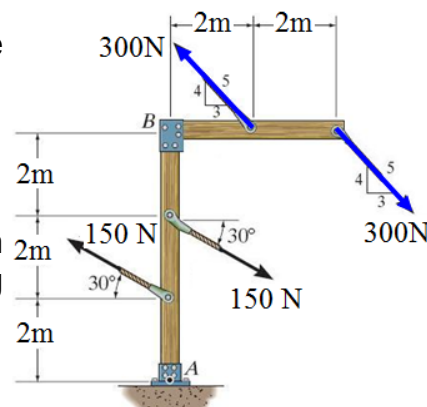2) Add the two couples to find the resultant couple.

EXAMPLE 3

The x and y components of the upper-left 300 lb force are:

(4/5)(300 lb) = 240 lb vertically up
(3/5)(300 lb) = 180 lb to the left

Do both of these components form couples with their matching components of the other 300 force?
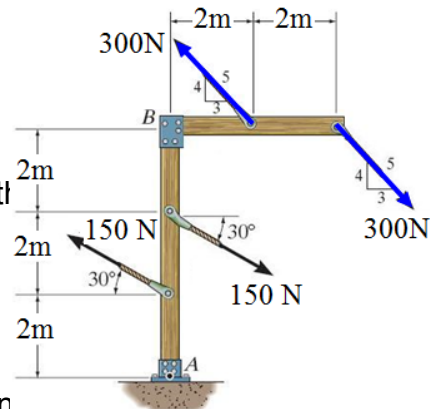

No! Only the 240 lb components create a couple. Why?

EXAMPLE 3

Now resolve the lower 150 force:

(150 lb) (sin 30°), acting up

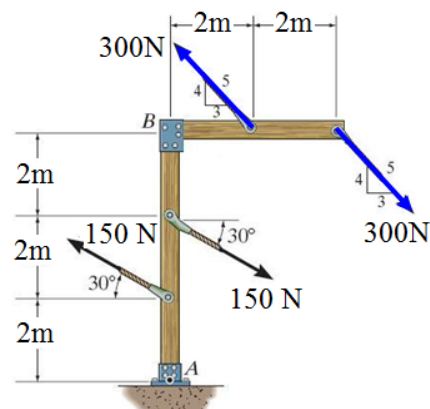(150 lb) (cos 30°), acting to the left

Do both of these components create a couple with components of the other 150 lb force?

EXAMPLE 3

The net moment is equal to:

$$\left(+\Sigma M = -(240 \text{ lb}) (2 \text{ ft})\right.$$
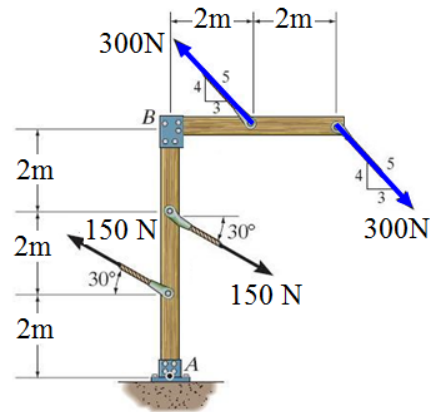
$$- (150 \text{ lb}) (\cos 30°) (2 \text{ ft})$$

$$\left(+\Sigma M = -480 - 259.8\right.$$

$$= -739.8 \text{ ft·lb CCW}$$

$$= 739.8 \text{ ft·lb CW}$$

EXAMPLE 3

The net moment is equal to:

$(+\Sigma M = -(240\ N)(2\ m)$

$\quad -(150\ N)(\cos 30°)(2\ m)$

$(+\Sigma M = -480 - 259.8$

$\quad = -739.8\ N.m\ \ CCW$

$\quad = 739.8\ N·m\ \ CW$

EXAMPLE 4

- ☐ Determine the moment of the force about point *O.* Neglect the thickness of the member
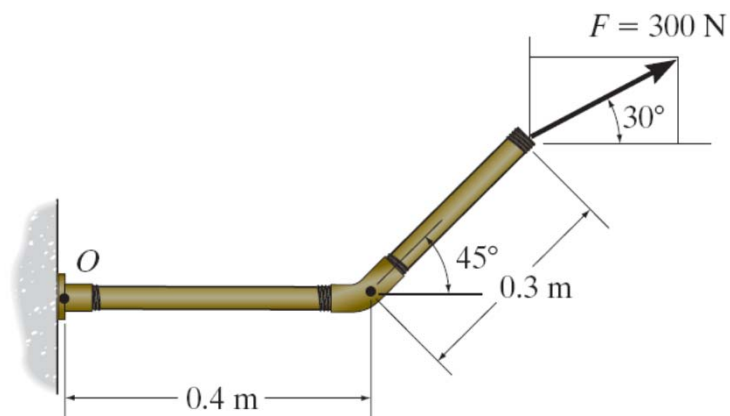
EXAMPLE 5

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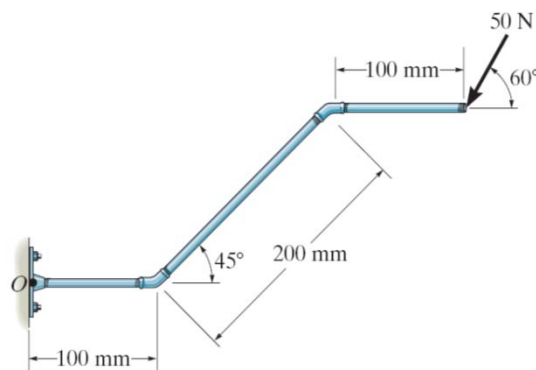
Determine the resultant moment produced by the forces about point O.
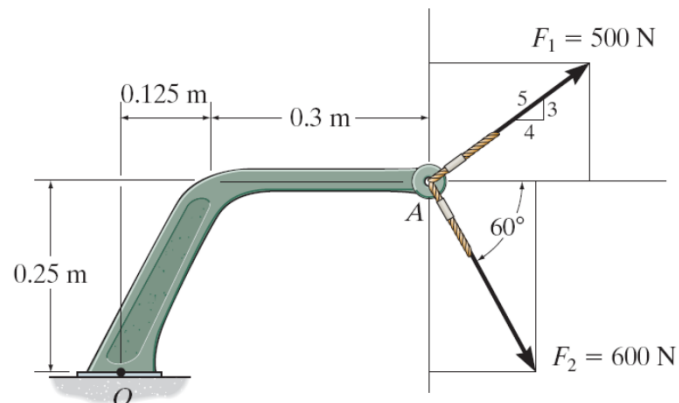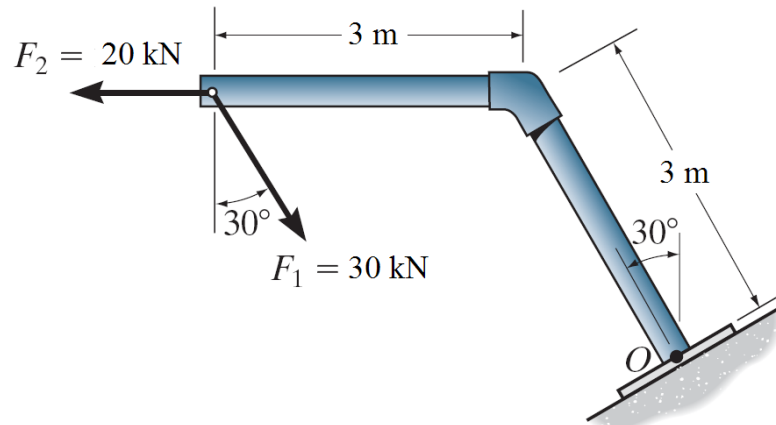

EXAMPLE 6

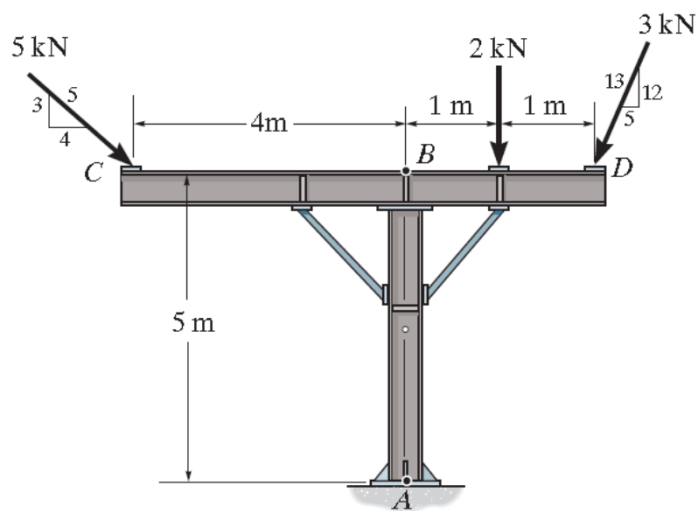**F 4–2.** Determine the moment of the force about point O.

EXAMPLE 7

F4–9. Determine the resultant moment produced by the forces about point O.

$F_2 = 20$ kN

3 m

30°

$F_1 = 30$ kN

3 m

30°

O

EXAMPLE 8

Determine the resultant force and couple moment at point A.

5 kN

3 5
4

C

4m

5 m

A

2 kN

1 m   1 m

B

3 kN

13 12
5

D

EXAMPLE 9

Determine the couple moment acting on the beam.